IS 3374 (1983): Preformed Steel Wire Ropes for Aircraft Controls [MED 10: Wire Ropes and Wire Products]

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*Indian Standard*

(Reaffirmed 2001)

# SPECIFICATION FOR PREFORMED STEEL WIRE ROPES FOR AIRCRAFT CONTROLS

*( First Revision )*



**1. Scope** — Covers specifications for preformed flexible steel wire ropes of 7×7 and 7×19 constructions made either of galvanized carbon steel wire or corrosion resisting steel wire, for aircraft controls.

**2. Terminology** — For the purpose of this standard, the terminology given in IS : 2363-1981 'Glossary of terms relating to wire ropes (*first revision*)' in addition to the following definitions shall apply.

**2.1** *Diameter*

**2.1.1** *Nominal diameter* — The value by which the diameter of the wire, strand or rope is designated.

**2.1.2** *Measured ( or actual ) diameter* — That diameter which is obtained by measuring in accordance with a prescribed method ( *see* **7.2.2** ).

**2.2** *Elongation* — The elastic elongation of a rope is the length by which the rope increases under a given load which is selected so as not to cause permanent deformation. This elongation is expressed as a percentage of the length of the rope ( *see* **7.4** ).

**2.3** *Length of Lay* — The pitch of the helix of the axis of the strand ( or wire ) in the longitudinal axis of the rope ( or strand ).

**3. Material**

**3.1** *General* — The cold drawn wire shall be produced from steel manufactured by any process other than the Bessemer process. It shall be free from defects deterimental to the performance of the rope and shall satisfy the requirements listed in the following clauses.

**3.2** *Chemical Composition of the Steel*

**3.2.1** *Carbon steel* — For chemical composition of carbon steel wire ropes refer IS : 1835-1976 'Specification for round steel wire for ropes ( *third revision* )', but with following limitations:

| Elements | Percentage *Max* |
|---|---|
| Sulphur | 0·040 |
| Phosphorus | 0·040 |
| Sulphur and phosphorus | 0·065 |

**3.2.2** *Corrosion resisting steel* — Refer Grade 07cr18Ni9 specified in IS : 1570 ( Part 5 )-1972 'Schedules for wrought steels: Part 5 Stainless and heat-resisting steels ( *first revision* )'.

**3.3** *Mechanical Properties of the Wire*

**3.3.1** *Carbon steel wire* — The tensile strength of any wire shall not fall outside the range given below for the appropriate tensile grade and nominal wire diameter :

| Nominal Wire Diameter mm | | Tensile Grade | Tensile Strength MPa ($N/mm^2$) |
|---|---|---|---|
| From | Up to and Including | | |
| 0·15 | 0·30 | 1 950 | 1 950 to 2 350 |
| 0·30 | 0·40 | 1 950 | 1 950 to 2 300 |
| 0·40 | 0·50 | 1 950 | 1 950 to 2 250 |

Adopted 28 June 1983



Gr 6

INDIAN STANDARDS INSTITUTION
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3.3.2 *Corrosion resisting steel wire* — The wire used for the wire rope, except for core or king wires, shall have a tensile strength of not less than that given below:

| Nominal Wire Diameter mm | | Tensile Strength, *Min* MPa ($N/mm^2$) |
|---|---|---|
| From | Up to But not Including | |
| 0·10 | 0·20 | 2 060 |
| 0·20 | 0·25 | 1 960 |
| 0·25 | 0·30 | 1 865 |
| 0·30 | 0·40 | 1 815 |
| 0·40 | 0·50 | 1 765 |

**Note** — The variation in tensile strength of all the wires in any one layer of the rope shall not be greater than 295 Pa ( $N/m^2$ ).

3.4 *Galvanizing* — Carbon steel wire shall be subjected to one of the two treatments given below.

3.4.1 *Zinc coating* — The minimum mass of zinc deposited shall be as follows*:

| | |
|---|---|
| For wires of 0·24 mm and smaller | 29 $g/m^2$ |
| 0·25 mm to 0·39 mm | 30 $g/m^2$ |
| 0·40 mm to 0·50 mm | 40 $g/m^2$ |
| Above 0·50 mm | 50 $g/m^2$ |

**Note** — If the hot-dip process is used, the purity of the zinc shall not be less than 98·5 percent.

3.4.2 *Tinning* — The minimum mass of tin deposited shall be as follows:

| | |
|---|---|
| For wires of 0·25 mm and smaller | 0·9 $g/m^2$ |
| 0·26 mm to 0·38 mm | 1·5 g/m |
| 0·39 mm and larger | 3·0 $g/m^2$ |

## 4. Dimensions

4.1 *Size* — The nominal size of the rope shall be one of those given in Table 1. The actual diameter of the rope, at any point in its length measured over each pair of opposite strands, shall not exceed the values specified in Table 1.

## 5. Construction

5.1 The rope shall be of 7×7 or 7×19 construction according to the diameter of the rope specified in Table 1.

5.1.1 *7×7 construction* — This shall be composed of 6 outer strands each of 7 wires spun in a right-hand direction around a centre strand of 7 wires, with a length of lay of between 6 and 8 times the diameter of rope.

The centre strand shall be composed of a layer of 6 wires spun in a right-hand direction around a core or king wire. It shall be of sufficient diameter to give full support to the outer strands, and shall have a length of lay not exceeding 60 percent of the length of lay of the complete rope.

The 6 outer strands shall be composed of a layer of 6 wires spun in a left-hand direction around a core or king wire; they shall have a length of lay not exceeding 60 percent of the length of lay of the completed rope.

5.1.2 *7×19 construction* — This shall be composed of 6 strands of 19 wires spun in a right-hand direction around a centre strand of 19 wires.

*This refers to Type B of IS : 1835-1976.

TABLE 1 PRINCIPAL PROPERTIES OF WIRE ROPES
( *Clauses* 4.1, 5.1, 6.1, 7.2.2, 7.2.3 *and* 7.3.3 )

| Nominal Diameter | Construction | Measured Diameter | | Minimum Breaking Load | | Increase in Diameter After Cutting | Approx Mass per 100 m |
|---|---|---|---|---|---|---|---|
| | | *Min* | *Max* | Carbon Steel | Corrosion Resisting Steel | *Max* | |
| mm | | mm | mm | kN | kN | mm | kg |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1·6* | 7×7 | 1·6 | 1·8 | 2·15 | 2·15 | 0·23 | 1·2 |
| 2·4 | 7×7† | 2·4 | 2·7 | 4·10 | 4·10 | 0·25 | 2·4 |
| 3·2 | 7×19 | 3·2 | 3·5 | 8·90 | 7·85 | 0·28 | 4·6 |
| 4 | 7×19 | 4·0 | 4·4 | 12·45 | 10·70 | 0·43 | 6·7 |
| 4·8 | 7×19 | 4·8 | 5·2 | 18·60 | 16·50 | 0·48 | 9·7 |
| 5·6 | 7×19 | 5·6 | 6·0 | 24·9 | 22·25 | 0·51 | 12·8 |
| 6·4 | 7×19 | 6·4 | 6·8 | 31·20 | 28·40 | 0·53 | 16·4 |

*Only the principal properties of wire ropes having a diameter of 1·6 mm are given in this standard. The properties relevant to elongation and endurance tests for these wire ropes shall be introduced later.

†This wire rope may be of 7×19 construction, provided it has the required properties.

The centre strand shall be composed of a first layer of 6 wires spun in a left- or right-hand direction around a core or king wire, and a second layer of 12 wires spun in a right-hand direction. It shall be of sufficient diameter to give full support to the outer strands.

The 6 outer strands shall be composed of a first layer of 6 wires and a second layer of 12 wires spun in a left-hand direction around core or king wire.

**5.1.3** *Length of lay* — In the case of 7×19 construction, the length of lay of the centre strand and of the outer strands shall be as follows:

The inner layer of 6 wires shall have a length of lay of less than 60 percent of the length of lay of the outer layer.

The outer layer of 12 wires shall have a length of lay of less than 50 percent of the length of lay of the rope.

The 6 outer strands shall be closed around the centre strand in a right-hand direction with a length of lay between 6 and 8 times the diameter of the rope.

## 6. General Requirements

**6.1** *Mass of Rope* — The approximate mass per 100 m of wire rope for a particular size shall not exceed the values specified in Table 1.

**6.2** *Workmanship* — The completed rope shall be of uniform lay and shall be free from kinks, open and unequally tensioned strands and other irregularities.

**6.3** *Joints* — Twisted joints may be made in wires of diameter equal to or less than 0·20 mm. For wires of diameter greater than 0·20 mm the joints shall be made by electric welding or brazing. In the same strand, joints shall not be less than 6 m apart.

**6.4** *Lubrication* — During manufacture of the rope a suitable anti-friction compound, which shall retain its properties between the temperature of −55°C and +70°C and which shall have anti-corrosive properties, shall be applied to the wires and strands. When it is applied, the anti-friction compound shall not be heated above the upper temperature limits.

**6.5** *Rope Lengths* — Ropes shall be delivered in minimum lengths of 300 m; however, 20 percent of the rope ordered may be furnished in lengths between 150 and 300 m.

**6.5.1** Preformed rope is generally furnished in lengths of 300, 1 000, 1 500 or 3 000 m.

## 7. Tests

### 7.1 *General Procedure Requirements*

**7.1.1** Throughout the following tests the temperature and humidity shall be normal and constant.

**7.1.2** Before every inspection operation the inspector shall be satisfied that measuring instruments are correctly calibrated.

### 7.2 *Inspection of Production Lengths*

**7.2.1** *Visual examination* — All ropes shall be examined visually in order to check the quality of manufacture and finish. The distance between any two broken wires other than wires joined in accordance with **6.3** shall be at least 300 m.

**7.2.2** *Measurement of diameter* — The actual diameter of the rope shall be measured after production with a measuring device with jaws broad enough to cover not less than two adjacent strands. At each of three points spaced at least 10 m apart, two measurements shall be taken at right angles to each other. The average of these six measurements shall fall within the minimum and maximum diameters indicated in col 3 and 4 of Table 1. Each end of each manufactured length of wire rope shall be measured in this manner. This measurement shall be made on a straight portion of the rope under no tension.

**7.2.3** *Cutting test* — The increase in the diameter of the wire rope after cutting shall not exceed the value indicated in col 7 of Table 1. The measurement shall be made as near as possible to the end of the rope on both pieces. (This test may be carried out at the time of sampling for the various mechanical tests.)

### 7.3 *Breaking Strength of Rope*

**7.3.1** *Test length* — The test length/distance between grips, shall not be less than:

a) 300 mm for ropes having a diameter of 6 mm or less, and

b) 600 mm for ropes having a diameter of more than 6 mm.

**7.3.2** *Test piece* — The minimum length of test piece is made up of the test length plus an allowance for gripping. The test piece shall be representative of the rope as a whole and free from defects. Prior to selection the end of the test piece shall be secured to prevent turn being put into or taken out of the test piece. In the same way the rope from which the test piece is taken shall be secured. When cutting the test piece from the rope neither the rope nor the test piece shall be damaged. When testing a rope to destruction it may be provided with conical sockets. Care shall be taken to ensure that the casting material penetrate well into untwisted wires.

**7.3.3** *Testing* — Not more than 80 percent of the minimum breaking load given in Table 1 may be applied quickly, the remaining load shall be applied slowly, at a rate of application of stress of approximately 10 MPa per second. The actual breaking load is reached when no further increase of the load is possible.

**7.3.4** *Evaluation of test* — Tests in which breakage occurs in side or adjacent to the grips may be discarded at the option of the manufacturer in cases where the minimum breaking load is not reached.

### 7.4 *Elongation Test*

**7.4.1** *Preliminary procedure* — From each production length of wire rope a sufficient length shall be selected to provide an unobstructed test length of 250 mm minimum between the jaws of the test machine. This selected length shall be pre-stretched to remove constructional stretch and to bring the test length approximately into the elastic condition by the application of a load equal to 63 percent of the minimum breaking load as indicated in Table 2. This load shall be maintained for a period of at least 2 minutes and then released to not more than 5 percent of the minimum breaking load.

**7.4.2** *Test procedure* — On the test length thus prepared, and immediately following the preliminary procedure, the minimum gauge length of 250 mm shall be accurately measured, marked and recorded under an initial load equal to 5 percent of the minimum breaking load of the rope. The load shall then be progressively increased until a load equal to 60 percent of the minimum breaking load is reached and maintained for a minimum period of 1 minute. The length between the gauge points shall again be measured. The difference between the two measurements is the elongation and shall be expressed as

a percentage of the original gauge length. This percentage shall be in accordance with that given in Table 2.

The measurement shall be made with a comparator or any other instrument which has an accuracy of 0·01 mm.

**7.4.3** *Proof test* — Using the same test length as the elongation test ( **7.4** ), the load shall be progressively increased until a value of 80 percent of the minimum breaking load is reached and maintained for a minimum period of 5 seconds.

This load shall then be released and the test length completely separated into its constituent wires and each wire shall be examined.

Any broken wires shall be cause for the rejection of the production length represented by the test length.

**TABLE 2 ELONGATION TEST**
( *Clauses* 7.4.1 and 7.4.2 )

| Nominal Diameter mm | Breaking Load *Min* kN | | Prestretching Load 63 Percent of Minimum Breaking Load kN | | Load at 1st Reading 5 Percent of Minimum Breaking Load kN | | Load at 2nd Reading 60 Percent of Minimum Breaking Load kN | | Maximum Percentage Elongation × 100 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Gauge Length | |
| | C | RC | C | RC | C | RC | C | RC | C | RC |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 2·4 | 4·10 | 4·10 | 2·60 | 2·60 | 0·21 | 0·21 | 2·45 | 2·45 | 0·80 | 0·80 |
| 3·2 | 8·90 | 7·85 | 5·65 | 4·95 | 0·45 | 0·39 | 5·40 | 4·70 | 0·85 | 0·95 |
| 4 | 12·45 | 10·70 | 7·85 | 6·70 | 0·63 | 0·54 | 7·45 | 6·40 | 0·95 | 1·00 |
| 4·8 | 18·60 | 16·50 | 11·80 | 10·40 | 0·93 | 0·82 | 11·20 | 9·80 | 0·95 | 1·00 |
| 5·6 | 24·90 | 22·25 | 15·70 | 14·00 | 1·25 | 1·12 | 14·90 | 13·35 | 0·95 | 1·00 |
| 6·4 | 31·20 | 28·40 | 19·60 | 17·90 | 1·56 | 1·42 | 18·60 | 17·10 | 0·95 | 1·00 |

C = carbon steels, RC = corrosion resisting steels

**7.5** *Endurance Test* — The purpose of the endurance test is to check whether, after a determined number of alternating bends, the wire rope still has a breaking strength at least equal to the value given in Table 4.

**7.5.1** *Endurance test apparatus*

**7.5.1.1** *General conditions* — The machines shall be rigid enough to prevent the frame from being affected by movement during the test.

They shall be equipped with test pulleys made of steels having a minimum hardness of 60 *HRC* mounted on ball bearings.

The ball bearings shall be inspected before each test and shall be replaced when required.

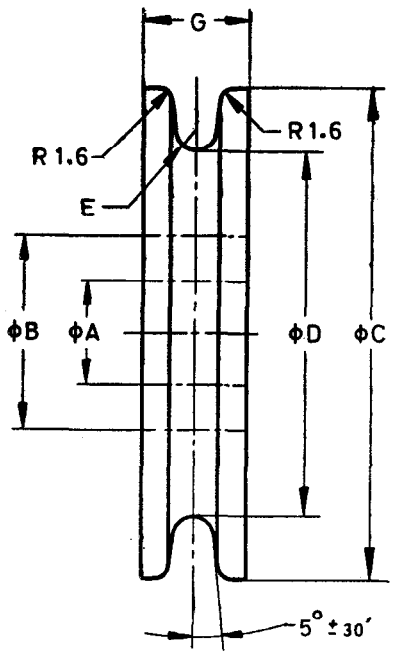
**7.5.1.2** *Special compulsory conditions for test machines to be used for the evaluation of a wire rope or the acceptance of a lot* — These test machines shall be in conformity with Fig. 1. They shall be equipped with a drum 420 mm in diameter, on which the wire rope is made fast. This drum is subjected to oscillations; the number of these (a function of the diameter of the wire rope) is given in Table 4.

The oscillation frequency shall be 120 direction reversals per minute $\pm 2$. It shall be recorded on a meter.

The pulleys shall be selected as a function of the diameter of the wire rope, and the dimensions shall be as given in Table 3.

**TABLE 3 DIMENSIONS OF PULLEYS FOR ENDURANCE TEST**

( *Clause* 7.5.1.2 )




*A* : Bore of the bearing
*B* : Bored for fixing the bearing to the press
*C* : Overall diameter of the pulley
*D* : Pulley diameter
*D*/*d*: Ratio of pulley diameter '*D*' to rope diameter '*d*'
Material : Tool steel treated for a hardness of 60 *HRC Min.*

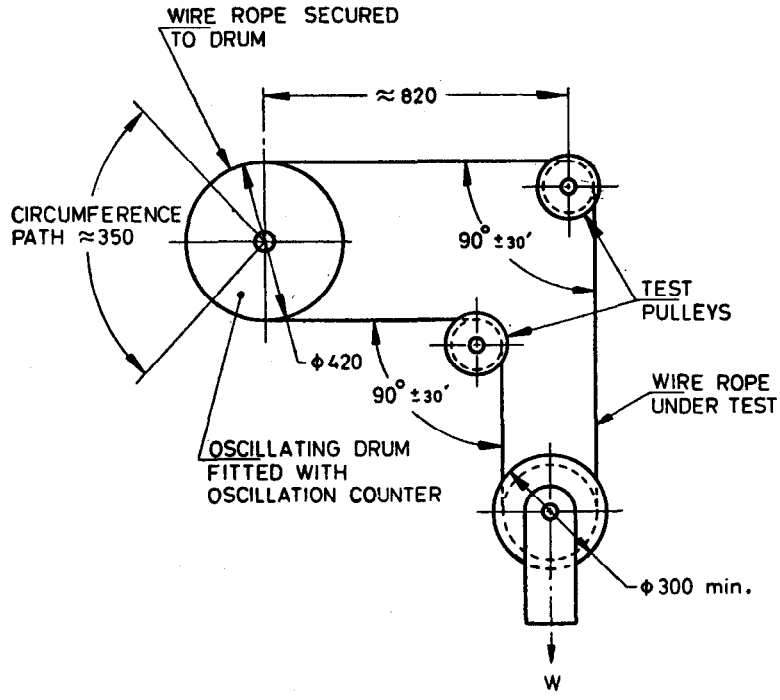
| Nominal Diameter, *d* mm | $\frac{D}{d}$ | *C* ±0·4 mm | *D* $^{+0·13}_{0}$ mm | *E* $^{+0·05}_{0}$ mm | *G* +0·4 mm |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 2·4 | 15 | 48 | 36 | 1·38 | 9·5 |
| 3·2 | 9·5 | 40 | 30 | 1·78 | 9·5 |
| 4 | 9·5 | 50 | 38 | 2·22 | 9·5 |
| 4·8 | 9·5 | 60 | 45 | 2·62 | 12·7 |
| 5·6 | 9·5 | 70 | 53 | 3·02 | 12·7 |
| 6·4 | 9·5 | 80 | 60 | 3·42 | 12·7 |

**7.5.1.3** *Performance conditions for endurance tests* — Additional lubricant shall not be applied to the wire rope either before or during the endurance test.

It should be possible to stop the test at any time for any reason, the test shall be restarted at the discretion of the operator, and operations carried out before the stoppage count for the test.

**7.5.1.4** *Final test* — After the prescribed number of oscillations, two test pieces shall be taken from the portions of the wire ropes in contact with the test pulleys; these are subjected to a breaking test. The lower of the two values obtained shall be at least equal to the value given in Table 4.

**7.5.2** *Test apparatus for wire rope testing* — Research and completion work on wire ropes and pulleys require test installations which are as close as possible to working conditions which might be encountered on an aircraft. Such work cannot be undertaken on the endurance test apparatus described in **7.5.1** as this apparatus, the main aim of which is to assess the quality of a wire rope, does not necessarily reproduce the real conditions in which the wire rope is found on an aircraft. (For example on an aircraft the pulley diameters represent more than 20 times the diameter of the wire, whereas on the endurance test apparatus the ratio is only 9·5).




All dimensions in millimetres.

FIG. 1 WIRE ROPE ENDURANCE TESTING MACHINE ( SCHEMATIC )

**TABLE 4 ENDURANCE TEST CONDITIONS**

( *Clauses* 7.5, 7.5.1.2 *and* 7.5.1.4 )

| Nominal Diameter, *d* | $\frac{D}{d}$ | Tension Applied to Wire Rope | Number of Oscillations | | Breaking Strength After the Oscillations | |
|---|---|---|---|---|---|---|
| | | | Carbon Steel | Corrosion Resisting Steel | Carbon Steel | Corrosion Resisting Steel |
| mm | | N | | | kN | kN |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 2·4 | 15 | 50 | 250 000 | 250 000 | 2·05 | 2·05 |
| 3·2 | 9·5 | 90 | 180 000 | 150 000 | 4·45 | 3·00 |
| 4 | 9·5 | 140 | 160 000 | 75 000 | 6·20 | 5·35 |
| 4·8 | 9·5 | 200 | 130 000 | 65 000 | 9·30 | 8·20 |
| 5·6 | 9·5 | 260 | 130 000 | 58 000 | 12·45 | 11·10 |
| 6·4 | 9·5 | 320 | 130 000 | 50 000 | 15·55 | 14·20 |

The use of the two test machines described below is therefore recommended for all research and completion work (for new wire ropes or for examining the running of a rope).

**7.5.2.1** *Test machine Type I* — ( *Refer Fig. 2* ) — The purpose of this machine is:

a) to study the behaviour of the pulleys with a given rope,

b) to check the results obtained for the various pulley/rope combinations over a rope-travel which is close to that on board an aircraft, and

c) to test a rope on several pulleys at a time.

The design of the machine allows for variation of parameters which may affect the behaviour of the rope, such as pulley diameter, angle, tensile stress, oscillation speed, etc.

**7.5.2.2** *Test machine Type II* — (*Refer Fig. 3*) — The particular purpose of this type of machine is rapidly to gather statistical information on the endurance properties of a given rope.

The design of the machine enables 8 ropes to be tested at once. The angle of 15° is constant and has been selected because it corresponds to the severest conditions during use.

It is possible to vary the tensile stress, the diameter of the pulley and the speed of the oscillations.

**8. Acceptance Conditions for Rope : Rejection and Re-test** — The failure of any specimen to comply with the requirements of **7.2.2** shall be a cause for the rejection of the wire rope from which it was taken, except that a manufacturer may at his own expense, in the presence of the inspector, take two further samples from each length of rope rejected, and subject these samples to a re-test. The inspector may accept a length of rope shown to conform to all the requirements of this standard by this re-test.

A complete report of the tests shall be prepared and supplied with the despatch documents.

**9. Storage and Packing**

**9.1** *Protection* — All carbon steel ropes shall be coated with a protective compound designed to shield them from corrosion before they are wound onto the reel on which they are despatched.

**9.2** *Packing* — The rope shall be wound on a reel designed for the purpose. The diameter of the barrel of the reel shall exceed 40 times the diameter of the rope. The flanges and the barrel of the wheel shall be covered with waterproof material and painted with a water-resistant compound before the rope is wound onto the reel. When it is fully wound, the exposed surface shall be covered with a layer of inert waterproof material held down by appropriate means.

**10. Marking**

**10.1** A label bearing the following information shall be attached to the innermost end left free:

a) Carbon (or corrosion-resisting) steel wire rope,

b) Length of the piece,

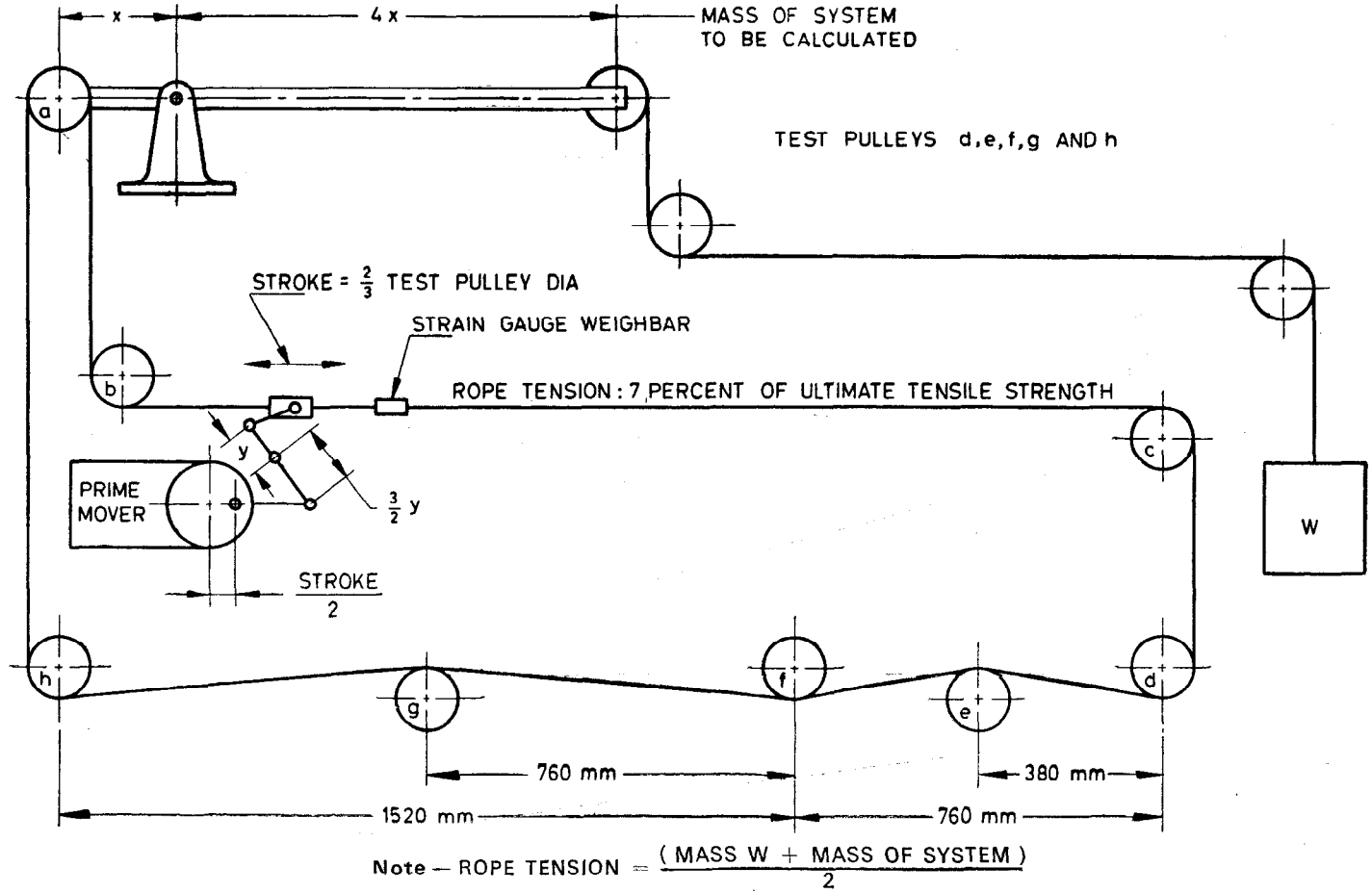
c) Nominal diameter and type of construction,

d) Manufacturer's name or identification marks,

e) Serial number of the rope, and

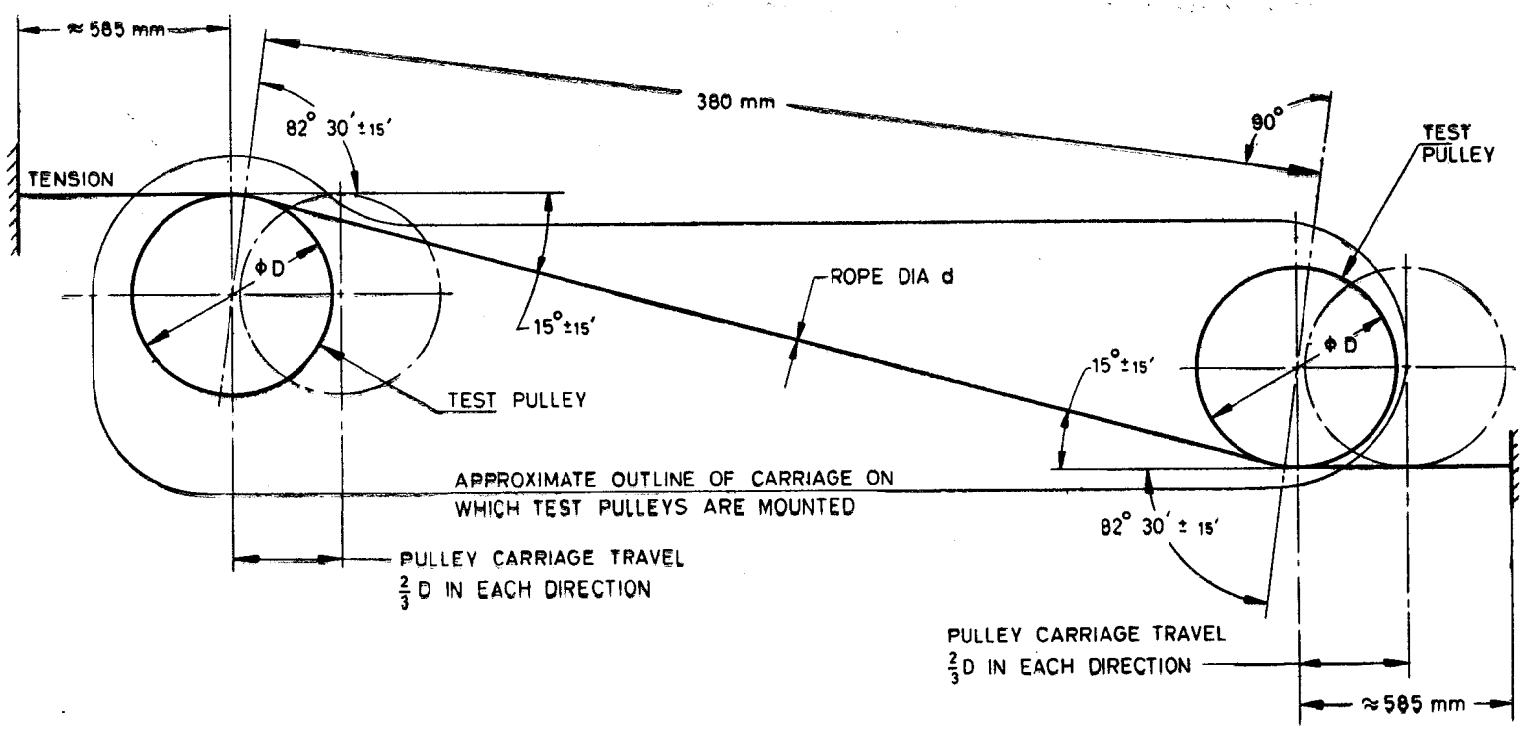
f) Any other information.

**10.1.1** *ISI Certification Marking* — Details available with the Indian Standards Institution.




Note — ROPE TENSION = $\frac{(\text{MASS W} + \text{MASS OF SYSTEM})}{2}$

FIG. 2 MACHINE TYPE I




CARRIAGE MOVEMENT 100 CYCLES/MINUTE
PULLEY DIA D = 'X' × ROPE DIA
'X' WITHIN 10 TO 30 RANGE

FIG. 3 MACHINE TYPE II

## EXPLANATORY NOTE

This standard was originally issued in 1965. Experience gained in the implementation of this standard over the past few years has necessitated this revision. However, this standard does not cover aircraft arrester wire ropes.

This standard has been completely revised and in this revised version corrosion resisting material has also been included.

While preparing this standard assistance has been taken from ISO 2020-1973 'Flexible steel wire rope for aircraft controls — Technical specification' issued by the International Organization for Standardization (ISO).



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